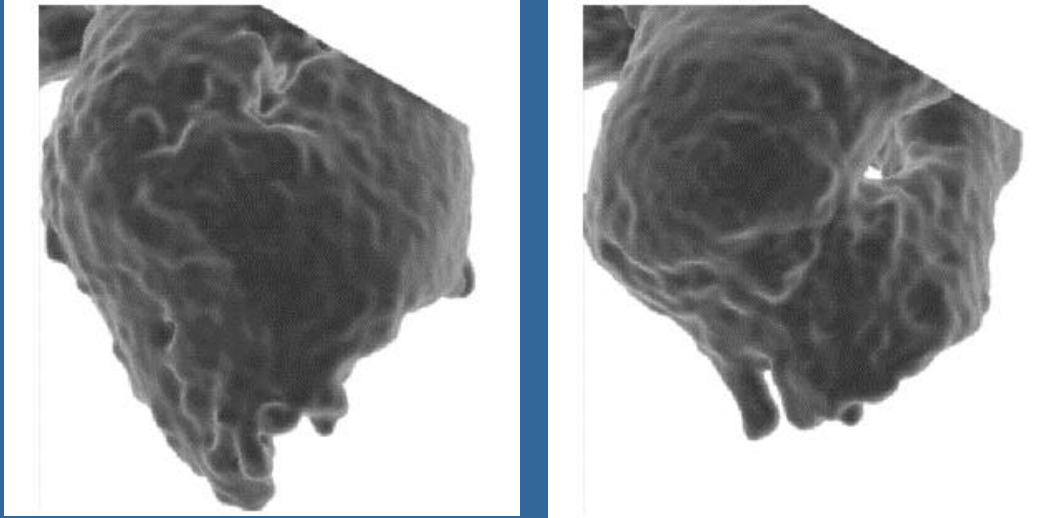


Medical Image Analysis

My research focus is development of computational methods for quantification of structure and function from medical images.

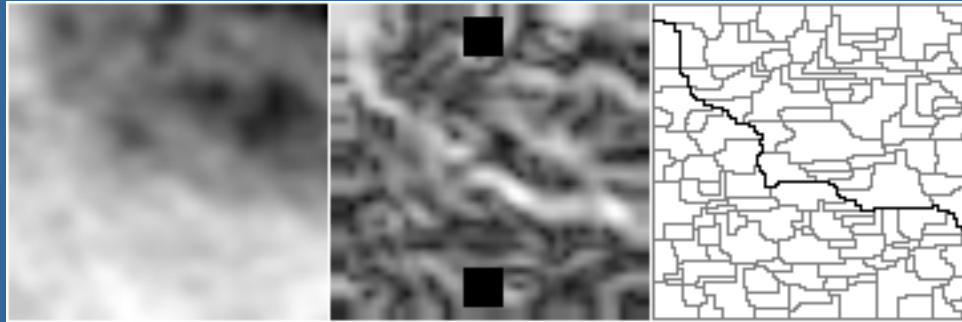
A variety of computational methods are presented in the following pages.



Cardiac Image Segmentation

The dynamic surface of the heart was reconstructed with the 4-dimensional marker-controlled watershed. Images were acquired with the Dynamic Spatial Reconstructor (DSR) at end diastole (left) and end systole (right). These reconstructions provide insight into the mechanical behavior of the heart.

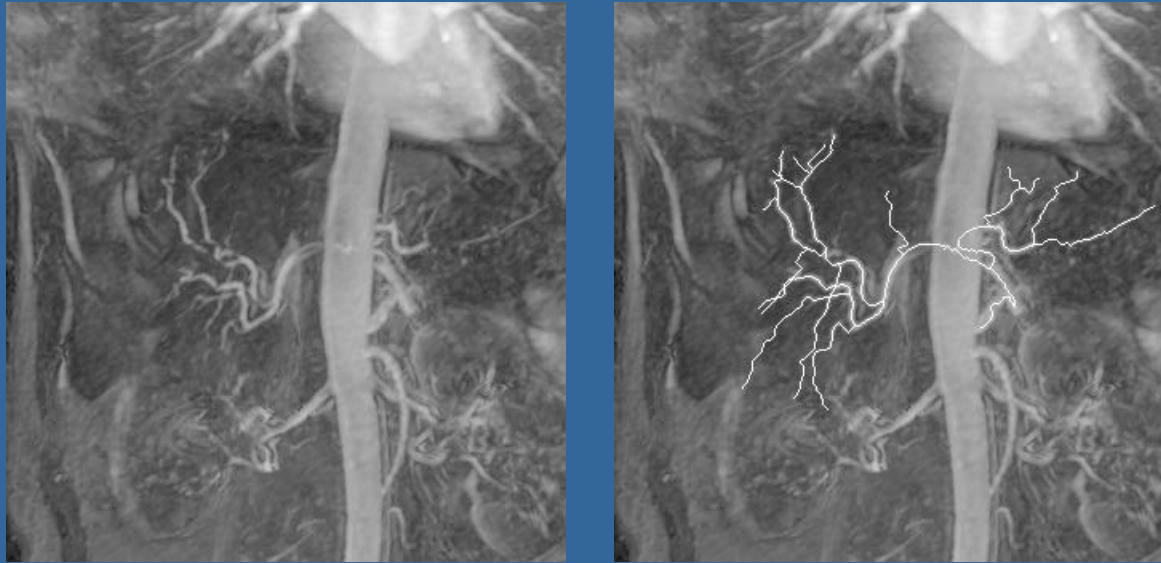
High-resolution four-dimensional surface reconstruction of the right ventricle and pulmonary arteries, Yim PJ, Kim D, Lucas CL, SPIE Proceedings, Volume 3038, pages 726-738, 1998.



METHOD:

The marker-controlled watershed

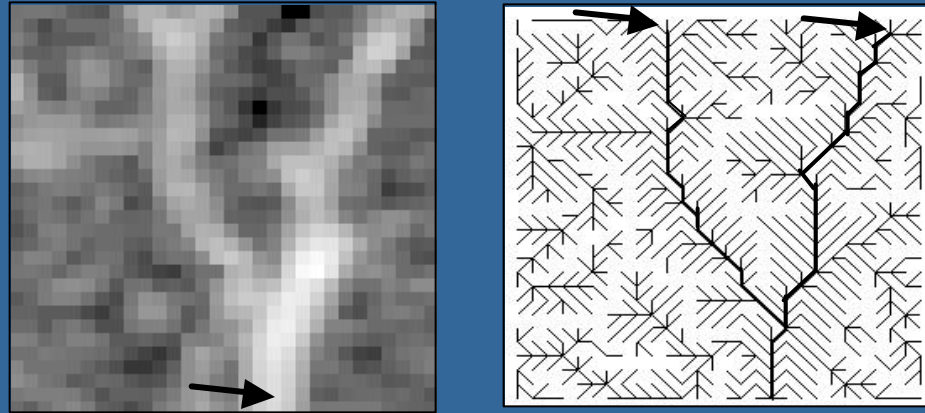
The marker-controlled watershed applied to a synthetic 2D image. Markers (black squares in this case) placed on a gradient image (center) propagate throughout the gradient image through flooding so as to produce a single line of separation (right – darker line).



Gray-scale skeletonization of magnetic resonance angiography

The maximum intensity projection (MIP) (left) does not show smaller vessels in the 3D image due to noise and overlapping high-intensity structures. Vessel paths are highlighted by picking points at the origin and terminus of each desired vessel and finding the path between the two points according to the Ordered Region Growing (ORG) algorithm (right).

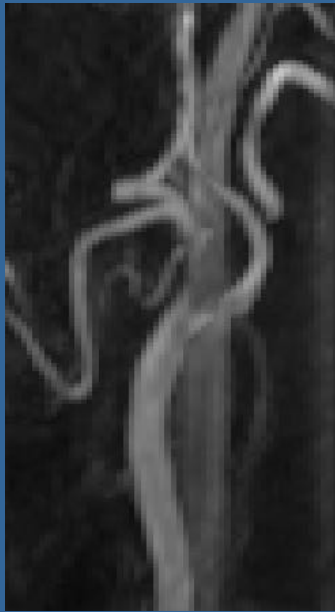
Gray-scale skeletonization of small vessels in magnetic resonance angiograms, Yim PJ, Summers RM, Choyke PL, IEEE Transactions on Medical Imaging, In Press.



METHOD:

Ordered Region Growing (ORG)

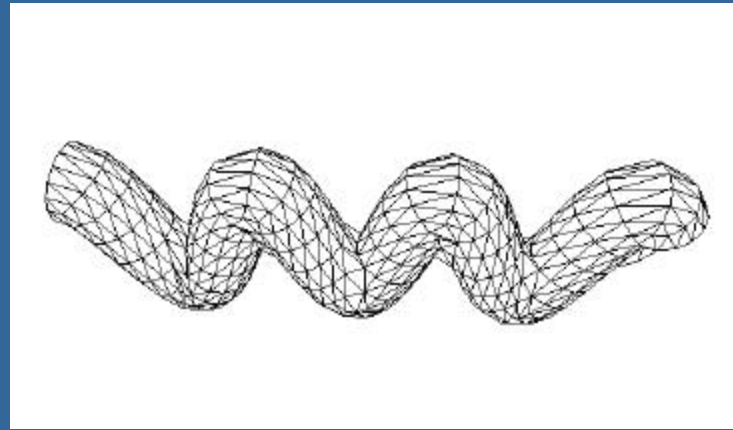
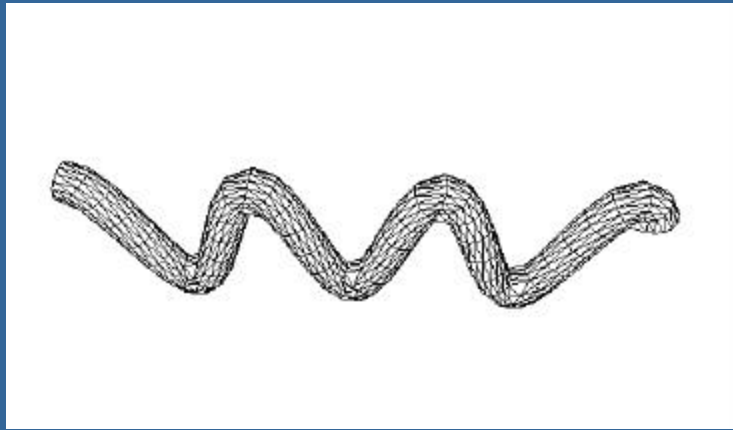
The ORG algorithm produces an acyclic graph which represents optimal paths in the image. The ORG was seeded at the point indicated by the arrow (left). Paths of high image intensity are detected by picking the endpoints of the path (right).



Artery-Vein Separation

Contrast enhanced MRA is often contaminated by signal from veins nearby to the arteries of interest. For example, the carotid artery bifurcation may be obscured by the jugular vein (left). The degree of stenosis of the carotid artery can be clarified by reconstructing the surface of the carotid artery using a 3D deformable model (right).

Measurement of stenosis from magnetic resonance angiography using vessel skeletons, Yim, PJ, Mullick R, Summers RM, Marcos H, Cebal JR, Lohner R, Choyke PL, Proc. of SPIE, Vol 3978, p245-255, 2000.



METHOD:

Tubular Geometric Deformable Model

The surface of a vessel is reconstructed from MRA images by finding the equilibrium position of a cylindrical mesh subject to external image forces and internal smoothing forces. For tubes with curved axes such as blood vessels, a non-self-intersecting mesh is constructed by mapping the cylindrical coordinate system to iso-distance surfaces surrounding the axes. An even distribution of vertices is obtained by merging nearby points on the mesh going from smaller (left) to greater radii (right).

Hemodynamics

Hemodynamic conditions in arteries can be determined using MRA that provides vessel shape and blood flow. We are investigating the use of computational fluid dynamics (CFD) to measure wall stress in a flow-through phantom of a carotid artery with stenosis.